WHAT IS CLAIMED IS:

1. A magneto–resistive element, comprising:
    an intermediate layer; and

5   a pair of magnetic layers sandwiching the intermediate layer;
    wherein one of the magnetic layers is a free magnetic layer in which magnetization rotation with respect to an external magnetic field is easier than in the other magnetic layer;
    wherein the free magnetic layer is a multilayer film including at

10 least one non–magnetic layer and magnetic layers sandwiching the non–magnetic layer; and
    wherein an element area, which is defined by the area of the intermediate layer through which current flows perpendicular to the film plane, is not larger than $1000 \mu m^2$.

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2. The magneto–resistive element according to claim 1, wherein an area of the free magnetic layer is larger than the element area.

3. The magneto–resistive element according to claim 1, wherein, when

20 the magnetic layers m are the magnetic layers in the free magnetic layer that are arranged at positions m (with m being an integer of 1 or greater) from the intermediate layer, Mm is an average saturation magnetization of the magnetic layers m and dm is their respective average layer thickness, then the sum of the products Mm×dm for odd m is substantially equal to the

25 sum of the products Mm×dm for even m.

4. The magneto–resistive element according to claim 3, the non–magnetic layer has a thickness d in the range of 2.6 nm ≤ d < 10 nm.

30 5. The magneto–resistive element according to any of claim 1, wherein, when the magnetic layers m are the magnetic layers in the free magnetic layer that are arranged at positions m (with m being an integer of 1 or greater) from the intermediate layer, Mm is an average saturation magnetization of the magnetic layers m and dm is their respective average

35 layer thickness, then the sum of the products Mm×dm for odd m is different from the sum of the products Mm×dm for even m.

6.   The magneto–resistive element according to claim 5, the non–magnetic layer has a thickness d in the range of $2.6 \text{ nm} \leq d < 10 \text{ nm}$.

7.   The magneto–resistive element according to claim 5, wherein the non–magnetic layer has a thickness d in the range of $0.3 \text{ nm} < d < 2.6 \text{ nm}$.

8.   The magneto–resistive element according to claim 5, wherein the free magnetic layer comprises a first magnetic layer, a non–magnetic layer and a second magnetic layer, layered in that order from the intermediate layer, and when an average film thickness of the first magnetic layer is d1, its average saturation magnetization is M1, an average film thickness of the second magnetic layer is d2, and its average saturation magnetization is M2, then
        $1.1 < (M1 \times d1 + M2 \times d2)/S < 20$;
(wherein S is the absolute value of $M1 \times d1 - M2 \times d2$); and
1) taking the effective film thickness d11 of the first magnetic layer as $d11 = (M1 \times d1 - M2 \times d2)/M1$ when $M1 \times d1 - M2 \times d2 > 0$, and
2) taking the effective film thickness d22 of the second magnetic layer as $d22 = (M2 \times d2 - M1 \times d1)/M1$ when $M1 \times d1 - M2 \times d2 < 0$,
     and taking as Nm the demagnetizing factor in a free magnetic layer surface in a direction of an applied external magnetic field, determined from the effective film thickness d11 or d22 and the free magnetic layer surface shape, then $Nm < 0.02$.

9.   The magneto–resistive element according to claim 5, wherein, when the free magnetic layer comprises a first magnetic layer, a non–magnetic layer and a second magnetic layer, layered in that order from the intermediate layer, and when an average film thickness of the first magnetic layer is d1, its average saturation magnetization is M1, an average film thickness of the second magnetic layer is d2, and its average saturation magnetization is M2, then
     $M2 \times d2 > M1 \times d1$; and
wherein the second magnetic layer is made of a soft magnetic material or a hard magnetic material, and the first magnetic layer is made of a high spin polarization material at least at an interface with the intermediate layer.

10.   The magneto–resistive element according to claim 5, wherein, when the free magnetic layer comprises a first magnetic layer, a non–magnetic

layer and a second magnetic layer, layered in that order from the intermediate layer, and when an average film thickness of the first magnetic layer is d1, its average saturation magnetization is M1, an average film thickness of the second magnetic layer is d2, and its average saturation magnetization is M2, then

$M2×d2>M1×d1$; and

the magnetic resistance displays at least one maximum or minimum with respect to a change in the external magnetization.

11. The magneto–resistive element according to claim 5, wherein the free magnetic layer comprises a first magnetic layer, a first non–magnetic layer, second magnetic layer, a second non–magnetic layer, and a third magnetic layer, layered in that order from the intermediate layer, and when an average film thickness of the magnetic layer n is dn, and its average saturation magnetization is Mn (with n = 1, 2, 3), then

$M3×d3>M1×d1$ and $M3×d3>M2×d2$; and

wherein a coupling magnetic field of the first magnetic layer and the second magnetic layer is smaller than a memory reversal magnetic field, and the magnetization state of the third magnetic layer is detected by applying a magnetic field that is smaller than the memory reversal magnetic field but larger than the coupling magnetic field in a memory direction of the magnetization of the third magnetic layer.

12. The magneto–resistive element according to claim 5, further comprising a second intermediate layer, wherein the free magnetic layer, which is made of a multilayer film, is sandwiched by the intermediate layers.

13. The magneto–resistive element according to claim 12, wherein the free magnetic layer, which is made of a multilayer film, is made of 2n magnetic layers (with n being an integer of 1 or greater) and 2n–1 non–magnetic layers layered in alternation.

14. The magneto–resistive element according to claim 13, further comprising a first pinned magnetic layer and a second pinned magnetic layer, wherein the first pinned magnetic layer, the first intermediate layer, the free magnetic layer, the second intermediate layer and the second pinned magnetic layer formed in that order, wherein the free magnetic layer is a

multilayer film comprising a first magnetic layer, a non–magnetic layer and a second magnetic layer formed in that order from the side of the first pinned magnetic layer, and wherein, when an average film thickness of the magnetic layer n (with n being 1 or 2) is dn, and its average saturation magnetization is Mn, then $M2 \times d2 \neq M1 \times d1$.

15. The magneto–resistive element according to claim 12, wherein the free magnetic layer, which is made of a multilayer film, is made of 2n+1 magnetic layers (with n being an integer of 1 or greater) and 2n non–magnetic layers layered in alternation.

16. The magneto–resistive element according to claim 15, further comprising a first pinned magnetic layer and a second pinned layer, wherein the first pinned magnetic layer, the first intermediate layer, the free magnetic layer, the second intermediate layer and the second pinned magnetic layer formed in that order, wherein the free magnetic layer is a multilayer film comprising a first magnetic layer, a first non–magnetic layer, a second magnetic layer, a second non–magnetic layer and a third magnetic layer formed in that order from the side of the first pinned magnetic layer, and wherein, when an average film thickness of the magnetic layer n is dn (with n being 1, 2 or 3), and its average saturation magnetization is Mn, then $M3 \times d3 + M1 \times d1 \neq M2 \times d2$.

17. The magneto–resistive element according to claim 1, wherein at least one of the magnetic layers in the free magnetic layer has a coercivity or saturation magnetization that is different from at least one of the other magnetic layers.

18. A magneto–resistive element comprising:
a magneto–resistive element A according to claim 5, wherein the free magnetic layer comprises a first magnetic layer, a non–magnetic layer and a second magnetic layer, layered in that order from the intermediate layer, and wherein $M2 \times d2 > M1 \times d1$, when an average film thickness of the first magnetic layer is d1, its average saturation magnetization is M1, an average film thickness of the second magnetic layer is d2, and its average saturation magnetization is M2;
and further comprising a magneto–resistive element B having a

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second intermediate layer and a free magnetic layer that comprises a third magnetic layer and a fourth magnetic layer positioned in that order from the second intermediate layer, and wherein M3×d3 > M4×d4, when an average film thickness of the third magnetic layer is d3, its average saturation magnetization is M3, an average film thickness of the fourth magnetic layer is d4, and its average saturation magnetization is M4;

wherein the element A and the element B respond to the same external magnetic field, and the output of element A and element B are added to or subtracted from one another.

19.   A magneto—resistive element, comprising:

an intermediate layer; and

a pair of magnetic layers sandwiching the intermediate layer;

wherein one of the magnetic layers is a pinned magnetic layer in which magnetization rotation with respect to an external magnetic field is more difficult than in the other magnetic layer;

wherein the pinned magnetic layer is a multilayer film comprising at least one non—magnetic layer and magnetic layers sandwiching the non—magnetic layer;

wherein a thickness d of the non—magnetic layer is in the range of 0.3nm < d < 2.6nm;

wherein the pinned magnetic layer is in contact with a primer layer or an antiferromagnetic layer; and

wherein an element area, which is defined by the area of the intermediate layer through which current flows perpendicular to the film plane, is not larger than 1000μm^2.

20.   The magneto—resistive element according to claim 19, wherein, when the magnetic layers m are the magnetic layers in the pinned magnetic layer that are arranged at positions m (with m being an integer of 1 or greater) from the intermediate layer, Mm is an average saturation magnetization of the magnetic layers m and dm is their respective average layer thickness, then the sum of the products Mm×dm for odd m is substantially equal to the sum of the products Mm×dm for even m.

21.   A magneto—resistive element comprising:

a magneto—resistive element A including a first pinned magnetic

layer, in which 2n magnetic layers and 2n−1 non−magnetic layers (with n being an integer of 1 or greater) are layered in alternation from the intermediate layer; and

a magneto−resistive element B, including a second pinned magnetic
5   layer, in n which 2n+1 magnetic layers and 2n non−magnetic layers are layered in alternation from the intermediate layer;

wherein at least one of the element A and the element B is as claimed in claim 19;

wherein the element A and the element B respond to the same
10   external magnetic field; and

wherein the outputs of element A and element B are added to or subtracted from one another.

22.   The magneto−resistive element according to claim 19, wherein the
15   non−magnetic layer comprises at least one compound selected from the group consisting of oxides, nitrides, carbides and borides.

23.   The magneto−resistive element according to claim 22, wherein the non−magnetic layer is a multilayer film including at least one layer of non−
20   magnetic metal and at least one layer of non−magnetic material selected from the group consisting of oxides, nitrides, carbides and borides.

24.   The magneto−resistive element according to claim 19, wherein the primer layer includes at least one element selected from the elements of
25   groups IVa to VIa and VIII (but excluding Fe, Co and Ni) and Cu.

25.   The magneto−resistive element according to claim 19, wherein the primer layer is in contact with a magnetic layer, and the primer layer and that magnetic layer have at least one crystal structure selected from fcc and
30   hcp structure, or the primer layer and that magnetic layer both include a bcc structure.

26.   The magneto−resistive element according to claim 19, wherein the antiferromagnetic layer is made of Cr and at least one selected from the
35   group consisting of Mn, Tc, Ru, Rh, Re, Os, Ir, Pd, Pt, Ag, Au and Al.

27.   The magneto−resistive element according to claim 26, wherein the

antiferromagnetic layer has a composition that can be expressed by $Cr_{100-x}Me_x$ (wherein Me is at least one selected from the group consisting of Re, Ru and Rh, and $0.1 \leq X \leq 20$).

28.   The magneto–resistive element according to claim 19, wherein the antiferromagnetic layer has a composition that can be expressed by $Mn_{100-x}Me_x$ (wherein Me is at least one selected from the group consisting of Pd and Pt, and $40 \leq X \leq 55$).

29.   The magneto–resistive element according to claim 19, wherein the antiferromagnetic layer is formed on a primer layer, and the primer layer and the antiferromagnetic layer include at least one crystal structure selected from fcc, fct, hcp and hct structure, or the primer layer and the antiferromagnetic layer both include a bcc structure.

30.   The magneto–resistive element according to claim 29,
wherein the primer layer is made of NiFe or NiFeCr; and
which has been thermally processed at a temperature of at least 300°C.

31.   The magneto–resistive element according to claim 19, wherein at least the magnetic layer in contact with the antiferromagnetic layer is made of Co.

32.   The magneto–resistive element according to claim 19, wherein the magnetic layer in contact with at least one selected from the antiferromagnetic layer and the non–magnetic layer is made of a ferromagnetic material including at least one element selected from the group consisting of oxygen, nitrogen and carbon.

33.   The magneto–resistive element according to claim 19, wherein the magnetic layer in contact with at least one selected from the antiferromagnetic layer and the non–magnetic layer is made of an amorphous ferromagnetic material.

34.   The magneto–resistive element according to claim 19, wherein, when df is a thickness of the pinned magnetic layer, and da is a thickness of the

ferromagnetic layer, then

$$2nm \leq df \leq 50nm,$$
$$5nm \leq da \leq 100nm,$$
$$0.1nm \leq df/da \leq 5.$$

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35. The magneto–resistive element according to claim 1, further comprising a lower electrode made of a metal multilayer film, wherein the magneto–resistive element is formed on the lower electrode.

10 36. The magneto–resistive element according to claim 35, wherein the multilayer film has a multilayer structure including a highly conductive metal layer (i) having at least one selected from the group consisting of Ag, Au, Al and Cu as a main component, and a grain–growth suppression layer of an metal having at least one element selected from groups IVa to VIa and VIII as a main component, or (ii) of a compound selected from the group consisting of conductive oxides, conductive nitrides and conductive carbides.

37. The magneto–resistive element according to claim 19, further comprising a lower electrode made of a metal multilayer film, wherein the magneto–resistive element is formed on the lower electrode.

38. The magneto–resistive element according to claim 37, wherein the multilayer film has a multilayer structure including a highly conductive metal layer (i) having at least one selected from the group consisting of Ag, Au, Al and Cu as a main component, and a grain–growth suppression layer of an metal having at least one element selected from groups IVa to VIa and VIII as a main component, or (ii) of a compound selected from the group consisting of conductive oxides, conductive nitrides and conductive carbides.

30 39. The magneto–resistive element according to claim 1, wherein the intermediate layer is made of an insulator or a semiconductor including at least one element selected from the group consisting of oxygen, nitrogen, carbon and boron.

35 40. The magneto–resistive element according to claim 19, wherein the intermediate layer is made of an insulator or a semiconductor including at least one element selected from the group consisting of oxygen, nitrogen,

carbon and boron.

41.   The magneto–resistive element according to claim 1,
wherein the intermediate layer is made of at least one metal selected
from transition metals, or at least one conductive compound selected from
compounds of transition metals with oxygen, nitrogen and boron; and
wherein the element area is not larger than $0.01\mu m^2$.

42.   The magneto–resistive element according to claim 41, wherein at
least one of the magnetic layers sandwiching the intermediate layer
comprises a ferromagnetic material including oxygen, nitrogen or carbon, or
an amorphous ferromagnetic material.

43.   The magneto–resistive element according to claim 19,
wherein the intermediate layer is made of at least one metal selected
from transition metals, or at least one conductive compound selected from
compounds of transition metals with oxygen, nitrogen and boron; and
wherein the element area is not larger than $0.01\mu m^2$.

44   The magneto–resistive element according to claim 43, wherein at
least one of the magnetic layers sandwiching the intermediate layer
comprises a ferromagnetic material including oxygen, nitrogen or carbon, or
an amorphous ferromagnetic material.

45.   The magneto–resistive element according to claim 1, wherein the free
magnetic layer serves as a magnetic memory layer.

46.   The magneto–resistive element according to claim 19, wherein the
free magnetic layer serves as a magnetic memory layer.

47.   The magneto–resistive element according to claim 1, further
comprising a flux guide.

48.   The magneto–resistive element according to claim 47, wherein at
least a portion of the free magnetic layer serves as the flux guide.

49.   The magneto–resistive element according to claim 19, further

comprising a flux guide.

50. The magneto–resistive element according to claim 49, wherein at least a portion of the free magnetic layer serves as the flux guide.

51. The magneto–resistive element according to claim 1, wherein, when "a" is the longest width of the element shape of the free magnetic layer, and "b" is its shortest width, then a/b is in the range of $1.5 < a/b < 10$.

52. The magneto–resistive element according to claim 19, wherein, when "a" is the longest width of the element shape of the free magnetic layer, and "b" is its shortest width, then a/b is in the range of $1.5 < a/b < 10$.

53. A method for manufacturing a magneto–resistive element according to claim 1, comprising additional heat treatment in a magnetic field at 200°C to 400°C, after heat treatment at 300°C to 450°C.

54. A method for manufacturing a magneto–resistive element according to claim 19, comprising additional heat treatment in a magnetic field at 200°C to 400°C, after heat treatment at 300°C to 450°C.

55. A method for manufacturing a magneto–resistive element according to claim 1, comprising heat treatment in a magnetic field at 300°C to 450°C.

56. A method for manufacturing a magneto–resistive element according to claim 19, comprising heat treatment in a magnetic field at 300°C to 450°C.

57. A method for manufacturing a magneto–resistive element according to claim 1, comprising:

forming a multilayer film including an antiferromagnetic layer, a pinned layer, an intermediate layer and a free magnetic layer on a substrate;

providing a uniaxial anisotropy by performing heat treatment in a magnetic field at 200°C to 350°C;

performing additional heat treatment in a reducing atmosphere at 300°C to 450°C.

58. A method for manufacturing a magneto–resistive element according

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to claim 19, comprising:

forming a multilayer film including an antiferromagnetic layer, a pinned layer, an intermediate layer and a free magnetic layer on a substrate;

providing a uniaxial anisotropy by performing heat treatment in a magnetic field at 200°C to 350°C;

performing additional heat treatment in a reducing atmosphere at 300°C to 450°C.

59. A data communication terminal equipped with a plurality of magneto–resistive elements according to claim 1, wherein data that have been communicated by electromagnetic waves are stored in the free magnetic layers of the magneto–resistive elements.

60. A data communication terminal equipped with a plurality of magneto–resistive elements according to claim 19, wherein data that have been communicated by electromagnetic waves are stored in the free magnetic layers of the magneto–resistive elements.

61. The magneto–resistive element according to claim 12, comprising a first pinned magnetic layer, a first intermediate layer, a first free magnetic layer, a non–magnetic conductive layer, a second free magnetic layer, an second intermediate layer and a second pinned magnetic layer formed in that order, wherein at least one of the first free magnetic layer and the second free magnetic layer includes one or more magnetic layers and one or more non–magnetic layers layered in alternation.

62. The magneto–resistive element according to claim 61, wherein magnetic layers that are adjacent but spaced apart by a non–magnetic conductive layer are magnetized antiparallel to one another.

63. The magneto–resistive element according to claim 61, wherein the non–magnetic conductive layer has a thickness of 2.6nm to 50nm.

64. The magneto–resistive element according to claim 12, comprising four pinned magnetic layers, two free magnetic layers, and four intermediate layers, wherein at least one of the free magnetic layers is made of one or more magnetic layers and one or more non–magnetic layers layered in

alternation.

65.   The magneto–resistive element according to claim 1, comprising a pinned magnetic layer, an intermediate layer and a free magnetic layer, wherein the free magnetic layer is in contact with a buffer layer, wherein the buffer layer is made of a composition in which 10wt% to 50wt% of a non–magnetic element is added to a composition of a magnetic layer in contact with the buffer layer, and wherein the saturation magnetization of said composition is not more than 0.2T.

66.   The magneto–resistive element according to claim 65, wherein the buffer layer comprises at least one selected from the group consisting of Cr, Mo and W.

67.   The magneto–resistive element according to claim 19, comprising a pinned magnetic layer, an intermediate layer and a free magnetic layer, wherein the free magnetic layer is in contact with a buffer layer, wherein the buffer layer is made of a composition in which 10wt% to 50wt% of a non–magnetic element is added to a composition of a magnetic layer in contact with the buffer layer, and wherein the saturation magnetization of said composition is not more than 0.2T.

68.   The magneto–resistive element according to claim 67, wherein the buffer layer comprises at least one selected from the group consisting of Cr, Mo and W.

69.   The magneto–resistive element according to claim 1, wherein the free magnetic layer is made of at least one non–magnetic layer and magnetic layers sandwiching the non–magnetic layer, and wherein a total film thickness of the magnetic layers is at least 4nm.

70.   The magneto–resistive element according to claim 19, wherein the free magnetic layer is made of at least one non–magnetic layer and magnetic layers sandwiching the non–magnetic layer, and wherein a total film thickness of the magnetic layers is at least 4nm.

71.   The magneto–resistive element according to claim 1, wherein the

non–magnetic layer comprises at least one compound selected from the group consisting of oxides, nitrides, carbides and borides.

72.   The magneto–resistive element according to claim 71, wherein the non–magnetic layer is a multilayer film including at least one layer of non–magnetic metal and at least one layer of non–magnetic material selected from the group consisting of oxides, nitrides, carbides and borides.